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REVIEW

Accumulation of Heavy Metals in Soil-crop Systems

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The health concerns associated with heavy metal pollution (HMP) in agricultural soils have garnered attention on a global scale, and evaluations of the dangers to human health are based on research on the buildup of heavy metals in soil-plant systems. The pedosphere, hydrosphere, atmosphere, lithosphere, and biosphere all suffer from environmental pollution. As a result of the industrialization of many nations, heavy metal pollution is one of the most important environmental problems today. Heavy metal pollutants in the environment have been removed using a variety of ways, however these procedures have drawbacks such high cost, lengthy process times, logistical issues, and mechanical complexity. To use phytoremediation, which uses plants to remove, transport, and stabilize heavy metals from soil and water, one must understand the accumulation of heavy metals in plants and the function of plants in eliminating contaminants. Physiological and metabolic processes that enable plants to phytoremediator heavy metal-contaminated locations are now being optimized via genetic engineering techniques. This review investigated the accumulation of seven common heavy metals in soil agriculture systems: Cd, Cr, As, Pb, Hg, Cu, and Zn. It is reported that wheat was generally more prone than corn to acquire heavy metals. The seven heavy metals were ranked as follows, in ascending order of accumulation in grains: Pb < Cr < Zn < As < Cu < Cd < Pb < Cr < Cu < As < Hg.

Key words: Heavy metals, Soil, Accumulation, Pollution, Plants

One of the main sources of HMP is agricultural activity (Arora *et al.* 2008; Kabata-Pendias 2011; Christou *et al.* 2014). The issue of abnormally high levels of heavy metals in agricultural products because to heavy metal pollution (HMP) in the soil has received more attention in recent years. As the primary source of heavy metals in plants in soil-plant systems, heavy metal ions in soil pore water may ingest plant roots (McLaughlin *et al.* 2011). The number of heavy metals that plants absorb depends on their activity, as well as on the amount of organic matter and the pH of the soil (Sanders *et al.* 1987; Badawy *et al.* 2002; Xia 2006). The chemical form and redox state of heavy metals, soil clay content, iron and manganese oxide content, cation exchange capacity (CEC), plant species, climatic conditions, and irrigation with polluted water are a few additional factors that affect the distribution and transfer of heavy metals in soil-plant systems (De Matos *et al.* 2000; Aydinalp and Marinova 2003; Gall and Rajakaruna 2013; Neilson and Rajakaruna 2014). There are 500 million ha of land with 5 million locations of soil pollution worldwide, where the soils are contaminated by various heavy metals or metalloids, with current soil concentrations exceeding geo-baseline or regulatory standards (Liu *et al.,* 2018).

Accumulation of heavy metals in soil to crop

Zancheta *et al.,* (2015) reported that *Sorghum bicolor* L. was cultivated under Cd stress in a hydroponic culture was more resistant to Cd stress than *Canavalia ensiformis* L. Majewska and Kurek (2008) reported that, in Cd uptake and transport of *Festuca ovina* and *Secale cereale* plants, grass roots accumulated much more cadmium than rye roots and transported more to the above-ground organs of grass plants than rye.

Begonia *et al.* (2002) show that coffee weed (*Sesbania exaltata*) was successful to removing Pb from contaminated soils. Fourati *et al.* (2016) demonstrated that Ni was accumulated in higher level (1050 μg g^{-1} DW) in the aboveground part of *Sesuvium portulacastrum*. *Ghazaryan et al.* (2019) compared the capacity of *Melilotus ofcinalis* and *Amaranthus retrofexus* in remedying contaminated soils by Cu and Mo. Recently Yang *et al.* (2020) found the ability of three Napier grass varieties (*Pennisetum purpureum*) to Cd and Zn uptake in feld conditions and found that *P. purpureum* cv. Guiminyin accumulates the maximum contents of Cd (197.5 g ha^{-1}) and Zn (5023.9 g ha^{-1}) in their shoots. By using pot tests, Khalid *et al.* (2020) evaluated the ability of *Alternanthera bettzickiana* to extract Ni and Cu, and they discovered that after 8 weeks of treatment, this species accumulates twice as much Cu in shoots as the control. Increased bioaccumulation of mercury in the shoot and root of seedlings results in shorter rice plants (*Oryza sativa*), fewer tillers and panicles, lower yields, and shorter plant height (Kibra, 2008). Arsenic causes chlorosis, wilting, and stunted development in canola (*Brassica napus*) (Cox *et al*., 1996).

Factors influencing the accumulation of heavy metals

Heavy metal transport and buildup from soil to plants is a very complicated process influenced by a few variables, each of which has a different impact on the process through a variety of processes. Chemical forms of heavy metals, soil pH, organic matter content, plant species, climatic circumstances, and irrigation with polluted water are a few of the main influencing elements (Bali *et al*., 2010; Bennedsen *et al.,* 2012; Neilson and Rajakaruna 2014). A significant component controlling the transmission and accumulation of heavy metals is the organic acid exudation by plants (Badawy *et al*. 2002; Zeng *et al.* 2011). By changing the rhizosphere's nutrient-absorption pathways, they influence the intake of heavy metals.

Effects on soil microorganisms

Sobolev *et al.* (2008) indicated that the microbial biomass in the soil contaminated by Cu, Zn, Pb and other heavy metals were inhibited severely. The soil's microbial biomass near the mine was significantly lower than that far away from the mine. The effects of different concentrations of heavy metals and different heavy metals on soil microbial biomass were different. Bruins *et al.* (2000) found that low concentrations of heavy metals could stimulate microbial growth and increase microbial biomass while high concentrations could decrease soil microbial biomass significantly. In addition, the enzymes in the soil play an important role in the process of organic matter decomposition and nutrient cycling.

Effects of Heavy Metal Contamination on Agriculture

The application of sewage sludge, waste water irrigation, phosphate fertilizer, pesticides, and pig slurry are some of the methods by which heavy metals are introduced into soils. These methods include atmospheric pollution by metal-bearing particles, application of sewage sludge, waste water irrigation, and pesticides. One of the biggest environmental issues today is the result of the heavy metal poisoning of agricultural soils. Increased heavy metal uptake by crops due to excessive heavy metal deposition in agricultural soils from wastewater irrigation could impact the quality and safety of food in addition to contaminating the soil (Chabukdhara *et al.,* 2016). Because of the possible hazards to human health posed by the transmission of heavy metals from soil to crops to food, heavy metal accumulation in soil and plants is a growing source of worry. Numerous crops, including rice, soybeans, wheat, maize, and vegetables, have been implicated in the accumulation of hazardous metals in edible components. Because plant metabolic processes are inhibited, plants may experience significantly reduced growth, which can also lead to decreased crop output (Singh and Aggarwal, 2006). The soil-crop system's soil qualities and crop management practices, as well as dietary toxicity thresholds, can affect the accumulation of metals in agricultural crops (Cooper *et al.,* 2011).

Harmful effects of some heavy metals on human health

According to (Ayangbenro and Babalola, 2017) The effects of cadmium on human health include testicular atrophy, lymphocytosis, microcytic hypochromic anaemia, lung and prostate cancer, coughing, emphysema, headache, hypertension, kidney illnesses, and bone disease. such as brain damage, cardiovascular and respiratory disorders, conjunctivitis, dermatitis, and skin cancer have an impact on human health. Anorexia, chronic nephropathy, neuronal damage, high blood pressure, hyperactivity, sleeplessness, learning disabilities, decreased fertility, renal system damage, risk factor for Alzheimer's disease, and a shortened attention span are only a few of the negative effects of Pb on human health. Bronchopneumonia, chronic bronchitis, diarrhoea, emphysema, headaches, skin irritation, itching of the respiratory tract, liver illnesses, lung cancer, nausea, renal failure, reproductive toxicity, and vomiting are just a few of the health effects that Cr can have on people. Hg can affect a person's health in ways such as ataxia, attention deficit disorder, blindness, deafness, decreased fertility, dementia, vertigo, dysphasia, gastrointestinal discomfort, gingivitis, kidney problems, memory loss, pulmonary edoema, lowered immunity, and sclerosis. Cu has an impact on human health and can cause nausea, vomiting, anaemia, diarrhoea, liver and kidney damage, headaches, and metabolic abnormalities. Ni has an impact on human health in the form of nausea, lung and nasal cancer, kidney illnesses, dermatitis, dry cough, dizziness, and shortness of breath. Zn may cause ataxia, depression, gastrointestinal discomfort, hematuria, icterus, impotence, kidney and liver failure, lethargy, macular degeneration, metal fume fever, prostate cancer, seizures, and vomiting in humans.

CONCLUSION

To lower the hazards to human health provided by the presence of heavy metals in crops, crops with high capabilities for collecting Cd, As, Hg, Cu, and Zn should be avoided when choosing crops. The transfer and accumulation of heavy metals are influenced by a few factors, including soil texture, cation exchange capacity, root exudation, and especially soil pH and chemical forms of heavy metals. This study presented heavy metal accumulation equations for soil-plant systems that can help to assess the health risks of heavy metals. However, these equations have limitations. In order to incorporate the contribution of the many influencing elements into the accumulation equations, more study must be done.

CONFLICTS OF INTEREST

The authors declare that they have no potential conflicts of interest.

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